Working Tax Credit and labour supply: Treasury Economic Working Paper No.3

March 2008

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If you require this information in another language, format or have general enquiries about HM Treasury and its work, contact:

Correspondence and Enquiry Unit
HM Treasury
1 Horse Guards Road
London
SW1A 2HQ

Tel: 020 7270 4558
Fax: 020 7270 4861
E-mail: public.enquiries@hm-treasury.gov.uk

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Working Tax Credit and labour supply

Ian Mulheirn
HM Treasury

Mario Pisani
HM Treasury

Abstract

The Working Tax Credit (WTC) was introduced in April 2003. This was the first time a national programme of in-work financial support for people without children had been attempted in the UK. WTC eligibility for people without children is contingent upon claimants being at least 25 years old. This paper exploits the age-eligibility requirement to measure the effect of the policy on both employment probability and hours worked among the target group of low-wage people. Two estimation strategies are followed. First, a difference-in-difference approach is used to measure the effect of WTC alone. It is found that the introduction of WTC had a small positive effect on employment, with the policy estimated to have increased the employment probability of eligible people by 2.4 percentage points in the central model reported. WTC is also estimated to have led to a small decrease in average hours worked among those in employment, but the increase in the number of people employed offsets this effect, leading to no change in total hours worked among those eligible for the policy. Second, a regression-discontinuity approach is used to measure the net effect of all changes in financial support eligibility at age 25, including that for WTC. These results show that, prior to introduction of WTC, the wider policy environment induced a substantial deterioration in employment probability at age 25. The introduction of WTC ameliorates this pre-existing deterioration in work incentives, with no evidence of a sudden drop in employment probability at age 25 following the introduction of the new policy.

JEL reference: J38, J22, I38.

Keywords: Working Tax Credit, labour supply, difference-in-difference, regression discontinuity, employment probability

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CONTENTS

Introduction and summary

1.1 Two well-known findings of labour economics are that long spells of unemployment worsen future labour market outcomes, while increasing the generosity of out-of-work benefits reduces the cash gain to work[1] and therefore work incentives. To tackle both these effects simultaneously, in April 2003 the Government introduced a national policy of in-work support for people without children. It was part of the Working Tax Credit (WTC), which also provides in-work support to families with children.

1.2 This was the first time that a national programme of in-work financial support for childless people had been attempted in the UK. Previous in-work financial support policies had been aimed at families with children, as part of the government's attempts to tackle poverty by getting parents into work. Over 1.2 million childless individuals or couples were estimated to be eligible for WTC in 2003, with substantially more potentially eligible were they to move into work. If successful, WTC would point the way to a sustainable future strategy for tackling poverty and worklessness among childless people by addressing the problems described above.

1.3 WTC eligibility for people without children is contingent upon claimants being at least 25 years old. However, two other policies that provide financial support, primarily to those out of work, also become significantly more generous once the claimant reaches 25. Consequently the changes in financial support eligibility that occur when someone turns 25 have opposing effects on work incentives.

1.4 This paper analyses the impact of WTC on the labour supply of childless individuals by exploiting the age-eligibility requirement. It does this by comparing changes in employment and hours worked for people just over and just under the age of 25, effectively isolating the impact of the policy at the point of change. The analysis also looks at the net effect of all changes in financial support eligibility, including WTC, that occur at age 25.

Previous literature

1.5 This paper builds on existing literature estimating the effect of the previous system of financial support for working families, the Working Families' Tax Credit (WFTC), in place between 1998 and 2003. Most studies found that that policy increased the employment rate of lone mothers by between four and seven percentage points. In terms of methodology, this paper follows similar approaches to those used in the wider recent literature on labour market policy evaluation. These include papers by Stewart (2004), who looked at the UK National Minimum Wage, and De Giorgi (2005) who evaluated the UK New Deal for Young People.

Methodology

1.6 The empirical analysis in this paper uses data from the Labour Force Survey between 2001 and 2005. The first concern is to identify the group of individuals who are affected by the policy, since only those people might be expected to enter employment in higher numbers. Some eligibility criteria for financial support policies, such as age or number of children, are easy to spot in the data. But because the amount of WTC received is gradually reduced as income increases above a certain threshold, the earning capacity of individuals also has to be taken into account when identifying the eligible group. The difficulty here is that it is impossible to know how much workless individuals would earn if they entered employment, and therefore difficult to be sure

[1] The gain to work is the difference between net disposable income in work, and out-of-work financial support.

whether they would be eligible for WTC. There are two ways of determining this latent eligibility: to use data on qualifications as a proxy for earning capacity; or to use an imputation technique to predict workless people's wages based on the earnings of working people with similar characteristics. This paper employs both approaches.

1.7 Two estimation strategies are used to identify the effect of policy on the eligible group. First, this paper exploits the introduction of WTC to compare the outcomes of the target group (those over 25) before and after the policy launch against those for a group that is not affected by the policy (those under 25). This technique is known as difference-in-differences (DiD) estimation and can isolate the effect of WTC alone on employment and hours worked. Second, a Regression Discontinuity (RD) approach is used to measure the net effect of all changes in financial support eligibility at age 25, including that for WTC. The technique can be applied in a situation where the effect of a number of policies depends on an observable characteristic, in this case age, and where there is a known point of discontinuity, in this case at the age of 25.

Main findings

1.8 The main findings are as follows:

- The introduction of WTC had a small positive effect on the number of people employed, with WTC estimated to have increased the employment probability of eligible people by 2.4 percentage points when low **qualifications** are used as a proxy for eligibility;
- When using **predicted wages** based on individual characteristics to determine WTC eligibility, the estimated effect of the policy on employment probability is positive 3.3 percentage points, but this result is less reliable than the one using qualifications as a proxy;
- The effect of the policy on employment probability appears to be concentrated among **men**, with no evidence of an increase in the employment probability of WTC-eligible women in the sample;
- WTC is estimated to have led to a small decrease in average hours worked among those in employment, but the increase in the number of people employed offsets this effect, leading to **no change in total hours worked** among those eligible for the policy; and
- Prior to introduction of WTC, it is found that the wider policy environment induced a substantial deterioration in employment probability, of around 3.2 percentage points, when people became 25. The introduction of **WTC ameliorates this pre-existing deterioration in work incentives at age 25**, with no evidence of a sudden drop in employment probability found at age 25 following the introduction of the new policy.

Robustness and sensitivity

1.9 There are a number of robustness tests and sensitivity analyses that can be used to explore the consistency of these results. First, tests are conducted to ascertain whether the assumptions underlying difference-in-differences are sustained. Second, it is possible to explore the sensitivity of the results across age groups and time. Third, one can vary the definition of the eligible group. Finally, it is possible to test whether the policy had an effect at a spurious date of introduction. All these tests vary the results as expected and support the headline results of this paper.

Policy implications

1.10 Given the substantial size of the childless WTC eligible group, these results have implications for the future direction of policy. This evaluation shows that the policy was effective in encouraging people into work. As such, childless WTC points the way to a sustainable strategy for tackling worklessness and poverty by creating cost-effective work incentives, without the need for substantially higher minimum wages.

1.11 In the rest of the paper, Chapter 2 describes the policy, presents a brief theoretical framework, and reviews related empirical literature. Chapter 3 describes the eligible population and the sample used to test the policy effect. Chapters 4 and 5 outline the two estimation methods, difference-in-differences and regression discontinuity design, along with the key results for each method. Chapter 6 concludes by recapitulating the headline results and discussing relevant policy developments since 2003.

2 Working Tax Credit and labour supply

2.1 In-work support for families with children is not new in Britain, but such a policy directed at childless people is[1]. This chapter describes the new Working Tax Credit (WTC) and considers its theoretical rationale, before reviewing some empirical literature evaluating the labour supply effects of Working Families' Tax Credit (WFTC), the forerunner policy to WTC.

DESCRIPTION OF THE POLICY ENVIRONMENT

History

2.2 In-work support for families with children was introduced in Britain in 1971 with the Family Income Supplement, followed with the introduction of Family Credit in 1988 and WFTC in 1999[2]. WTC was introduced, alongside the Child Tax Credit (CTC), in April 2003. These new tax credits replaced the previous patchwork of support available, the largest element of which was WFTC. WTC departs from the previous tax credits in a number of ways, one of the most significant of which is the extension of in-work support to families without children (single persons or couples) working at least 30 hours per week. The aim of this aspect of the policy was to strengthen work incentives and "tackle the problem of persistent low income among working people without children"[3]. Eligibility among the childless population was restricted to those aged 25 or over.

WTC for childless people

2.3 For a single person over 24 years old and working 30-or-more hours per week WTC in 2004-05 was worth £2,210 per year. Under the new system this maximum award is tapered away at a rate of 37 pence for every pound above a household income of £5,060. This means that an individual could receive WTC on an income of up to £11,000 per year. For a couple the maximum support was £3,755 per year, enabling childless couples, with one person working 30 hours or more, to receive support on joint incomes of over £15,000. Only for those earning below the National Minimum Wage was it possible to receive the maximum WTC entitlement (i.e. self employed people).

2.4 The nature of the WTC 30-hour requirement creates a discontinuity in the budget constraint of low-paid workers. As the hourly wage rises, the amount of WTC remaining at 30 hours decreases. For sufficiently well-paid individuals (over about £7 per hour), the credit provides no additional incentive to work, since all of the award is withdrawn by the time they have worked 30 hours. In this way the policy targets the biggest incentives at the group most likely to face poor work incentives: low productivity workers.

2.5 Chart 2.1, below, shows the relationship between gross earnings and disposable income, mediated through the tax and benefit system for a single childless person over the age of 25. The diagonal dotted line represents exact correspondence between gross income and disposable income: the no tax, no benefit world. Under the existing tax and benefit system, the person receives financial support when out of work from Income Support/Jobseeker's Allowance (IS/JSA), Housing Benefit (HB) and Council Tax Benefit (CTB). The chart shows how that support is withdrawn as the person earns a higher

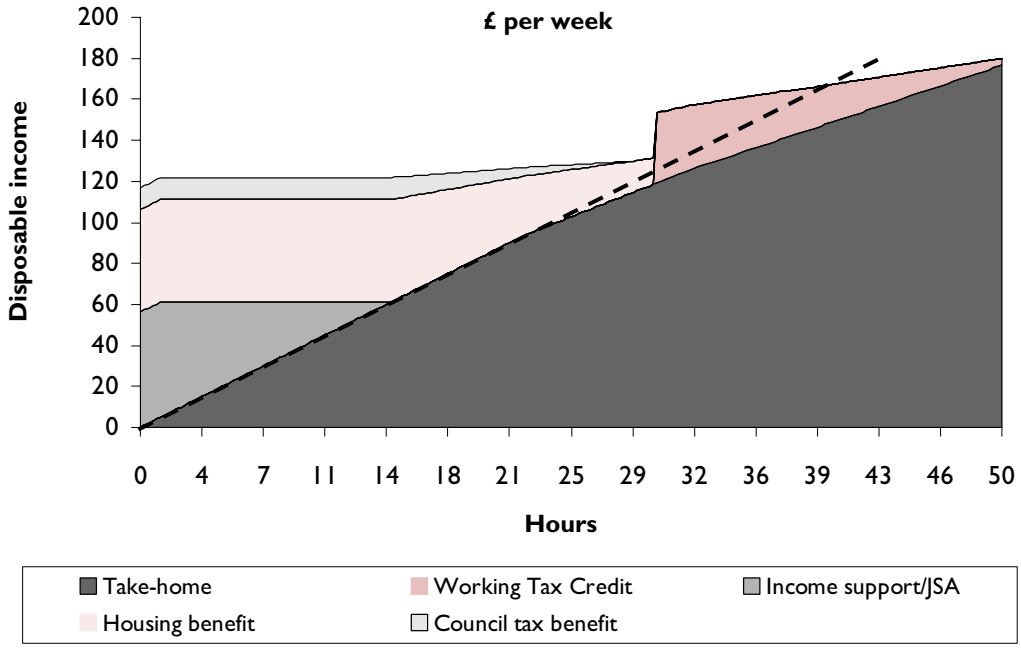
[1] Early forerunners to the idea of a negative income tax can be traced back as far as the Speenhamland system, which operated in parts of England in the early 19th Century.

[2] A non-national precedent exists: in 1996 the Department for Social Security launched the Earnings Top-Up pilots, which aimed to subsidise the wages of low-paid workers without children.

[3] *The Child and Working Tax Credits: The Modernisation of Britain's Tax and Benefit System, Number Ten* (HM Treasury, 2002)

income, represented by a number of hours at the contemporary minimum wage (£4.20 per hour). Chart 2.1 also shows what WTC does to the budget constraint of such a person, creating a jump in disposable income when the person moves from 29 to 30 hours.

Chart 2.1: Budget constraint for a 25-year-old minimum wage earner



Source: authors' calculations

Other age-contingent policies at age 25

2.6 IS/JSA provides £44.50 per week for a single person aged 18-24. Once the individual is 25 they become eligible for the higher single person rate of £56.20 per week. The award includes an earnings disregard so that a person can earn a small amount without having any of their award withdrawn. After that the entitlement is reduced by £1 for every £1 earned until the entitlement is zero, or until the person is working 16 hours, at which point any remaining entitlement is withdrawn.

2.7 Another major source of support is Housing Benefit (HB). Unemployed under-25s are entitled to claim for the entirety of their housing rental costs up to the market rental value of a single room in a shared house. This is typically about £60 per week[4]. Once 25, the same individual can claim the full value of their housing cost up to some level deemed reasonable by the local authority. As a result, an individual living alone will be able to get far greater financial support through HB once 25. Claimants are entitled to maximum HB (the full value of their rent) provided they continue to receive IS/JSA. Once IS/JSA has been withdrawn HB starts to be taken away at a rate of 65 per cent. The increased generosity of each of these policies for claimants aged 25-and-over significantly lowers the relative return to working.

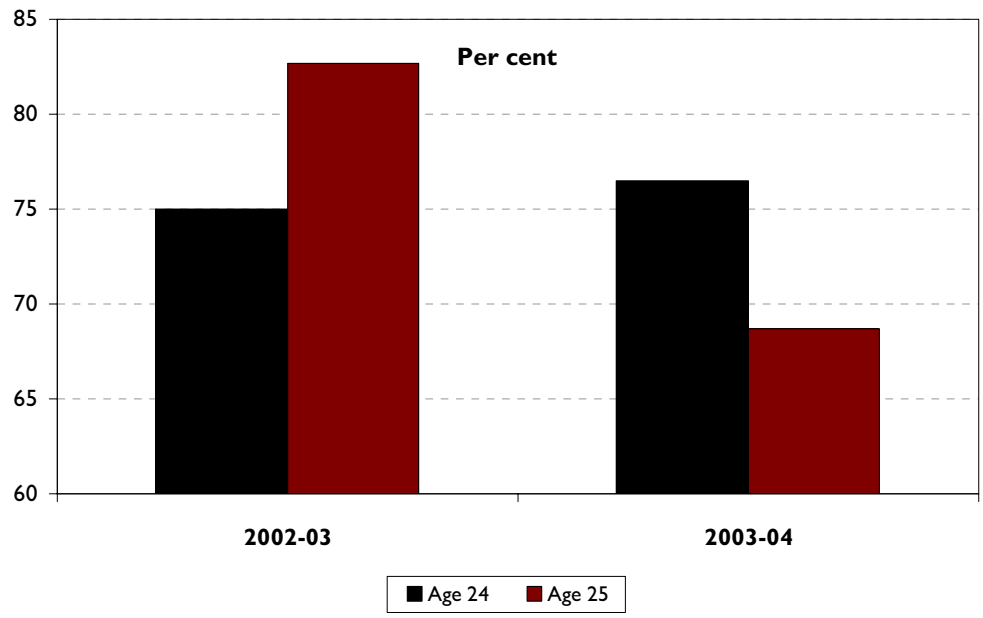
[4] Family Resources Survey 2003-04

2.8 A final element of the policy environment is the end to eligibility for the New Deal for Young People (NDYP) at age 25. NDYP provides unemployed young people with up to 12 months' subsidised on-the-job training or education. The impact of NDYP at 25 is mitigated by the existence of a (albeit less intensive) New Deal 25+ programme, and by the fact that many continue to participate in NDYP if they qualified for the programme when 24.

Change in work incentives at 25

2.9 As a single childless person turns 25, the combined effect of the benefit eligibility rules prior to April 2003 was substantially to reduce the gain to work and increase the average effective tax rate (AETR)[5] they faced. As Chart 2.2 shows, the introduction of WTC radically changed this, causing AETRs to drop by some 14 percentage points for those on the contemporary National Minimum Wage.

Chart 2.2: Work incentives, single person earning contemporary minimum wage, above and below 25



Source: authors' calculations

THEORY

2.10 There is a clear theoretical rationale for in-work support policies. Governments recognise the benefits of providing some minimal financial safety net for all members of society including those of working age. However, such a safety net involves the concomitant dilemma of how to withdraw the financial support as an individual progresses up the income distribution. High rates of withdrawal damage work incentives, while low rates cost more as they involve making payments to people further up the income distribution, who were not the initially intended recipients of the support. Lower withdrawal rates also have the side-effect of putting more people on

[5] AETR = 1-(Gain to work/Gross income)

high marginal deduction rates[6] thereby (theoretically) reducing their incentives to progress in work or work longer hours.

Theoretical framework

2.11 WTC entitlement is based upon household income, which means that, strictly, it differs from a wage subsidy. However, for individuals (and childless couples if one is happy to treat these as one unit) WTC can be considered to be a wage subsidy, which can be analysed in the same way as the negative income tax first proposed by Milton Friedman in 1962[7].

2.12 The basic idea of wage subsidy programmes, such as negative taxation and WTC, is to lower the withdrawal rate of financial support to those on low incomes, thus reducing the worker's AETR. A lower AETR allows an individual is able to reach a higher indifference curve for a given amount of work since they have a higher income. The increase in the return to work generates a positive substitution effect of work for leisure for those not previously working. For people who were employed to begin with, the income and substitution effects of the negative income tax both act to reduce hours of work (although never cause the beneficiary to leave work entirely). This is because the worker can achieve the same income as before the introduction of the negative income tax, while spending less time at work.

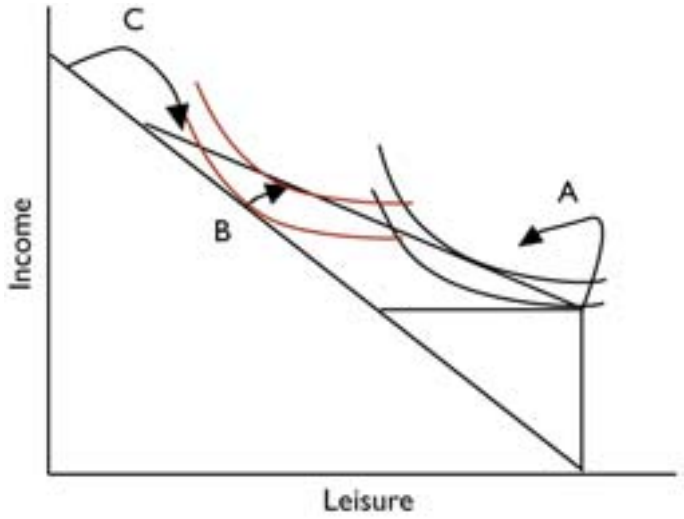
2.13 The cost of improving work incentives through in-work support is, however, dependent upon the level of minimum income guaranteed to individuals who do not work. With higher levels, for any given withdrawal rate, the negative income tax will involve people further up the income distribution. It is often argued that the immediate cost of such a scheme is outweighed by the impact it would have on labour supply. This would more likely be true if the labour supply effects of wage subsidies were unambiguously positive, but this is not the case, from a purely theoretical perspective.

2.14 The reduction of the 100 per cent effective tax rate for benefit recipients facing a pound-for-pound reduction in their entitlement unambiguously improves the work incentives faced by this group. They may now decide to work for some positive number of hours per week, where this may not have been in their interests under the pound-for-pound withdrawal regime. The change for such an individual is represented by the black line indifference curves in Figure 2.1. The incentive is to increase labour market participation as shown by arrow A. This occurs because the new financial support is unavailable to those not working, so there is no negative income effect for those working zero hours, while the substitution effect is positive. The net effect on participation should therefore be unambiguously positive.

[6] The marginal deduction rate is the combined rate at which tax is paid and benefits withdrawn.

[7] M. Friedman (1962) *Capitalism and Freedom*

Figure 2.1: Ambiguous impact of lower withdrawal rates



2.15 However, for those not previously on any form of negative tax or tax credit taper, it is now possible for them to increase their disposable income and reduce the hours they work. This unambiguously negative effect on labour supply at the intensive margin occurs because both the income and substitution effects are working in the same, negative direction (under the assumption that both leisure and income are normal goods). Arrow B in Figure 2.1 illustrates the move to the higher red indifference curve that may be undertaken by someone on this part of the income distribution. Finally, for those above the newly-extended taper of a negative income tax policy, there may be an incentive to reduce their income and hours of work, and move onto the taper to a new point of indifference curve tangency (not shown). This move is represented by arrow C. Whether this occurs depends entirely on the tastes of the individuals and their willingness to substitute income for leisure at the margin.

2.16 The overall effect on labour supply of lowering the withdrawal rate by extending the taper up the income scale is therefore ambiguous, while it is unambiguously positive on employment. Consequently if the policy's aim is to increase the hours of work supplied in the labour market, the justification must rest upon either: empirical observations that demonstrate the net effect to be positive; or a societal welfare function that weighs the benefits of providing incentives to those at the bottom of the distribution more than it does the costs of weakening incentives for those further up. Alternatively, if the policy priority is to increase employment or tackle poverty, as in the case of WTC, then theory provides unambiguous justification.

Hours rule

2.17 Under the WTC for people without children, the theoretical picture is complicated slightly by the existence of a 30-hour work requirement before the individual or couple qualify for the payable credit. This is very different from the Earned Income Tax Credit in the United States, under which the level of subsidy is related only to income. The hours rule has a number of interesting effects.

2.18 Firstly, the fact that (in 2003-04) the credit is withdrawn at a rate of 37 pence for each pound earned above £5,060 per year, means that the system does not put higher-productivity (and therefore higher pay-rate) workers onto any incentive-damaging taper since their eligibility will be zero by the time they reach the 30-hour qualification. Denying these high productivity workers support is justified by the reasoning that if their higher earning-power is insufficient to encourage them to work, then the costs of providing them with a WTC incentive would probably outweigh the benefits in terms of inducing them to work.

2.19 Secondly, it provides positive work incentives to people on low hourly pay rates who previously worked less than 30 hours. The size of the subsidy when claimants work 30 hours provides a significant boost to disposable income for those on hourly wages of up to around £7.

2.20 Under a strictly income-based credit, theory suggests that the effect on intensive labour supply among those ex ante in employment is predicted to be unambiguously negative. But the 30-hour requirement makes the overall effect on average hours among those in work ambiguous. In the presence of WTC those previously working less than 30 hours (including those not previously working at all) face improved incentives to move above that threshold, while those working over 30 can reduce their hours towards that point without being worse-off than they were before the introduction of the policy. This element of the design of the system makes it possible that the effect on intensive labour supply among those in employment before the policy's introduction will not be negative.

EXISTING LITERATURE

2.21 Similar theoretical predictions, for other child-dependent policies, have been empirically tested in the past. Most are attempts to evaluate the impact of the previous financial support system, WFTC, on the labour supply of people with children, focusing primarily on the impact on lone parents.

Recent evaluation literature

2.22 Brewer et al. (2005) use a structural model of individuals' preferences for work and income to analyse the effect of WFTC on labour supply and take-up. They estimate that WFTC increased the labour supply of lone mothers by around 5.11 percentage points, reduced the labour supply of mothers in couples by 0.57 percentage points, and raised that of fathers in couples by about 0.75 percentage points. They also conclude that the net effect of all other tax and benefit reforms of the period ran counter to the generally positive labour supply impact of WFTC.

2.23 Francesconi and Van der Klaauw (2004) use longitudinal data from the British Household Panel Survey to analyse the labour supply impact of WFTC. The authors use a difference-in-differences (DiD) approach to isolate the policy effect. The analysis indicates that WFTC increased the proportion of lone mothers working 16 hours or more by about 7 percentage points, and that of mothers working 30 hours or more by 9 percentage points. They find evidence that some of the effect was anticipated.

2.24 Blundell et al. (2005) also use a DiD approach, and find that following WFTC introduction the employment probability of lone mothers increased by 3.6 percentage points, when using Labour Force Survey data, or 3.7 percentage points, when using Family Resources Survey data.

2.25 Gregg and Harkness (2003) examine the package of reforms introduced in 1998/99 to assess their impact on lone parent employment and hours worked. The authors take a DiD approach. They also use propensity score matching to control for differences in observed characteristics between lone parents and the control group. The results show a positive 4.6 percentage point effect on lone parent employment rates. Given the Brewer et al. finding of a net negative effect on lone parent employment of reforms other than WFTC in this period, this result supports that of Francesconi and Van der Klaauw in suggesting WFTC had a large positive impact on this group.

2.26 Leigh (2005) also investigates the effect of WFTC on employment probability, and finds that the policy increased the participation rate of all adults with children by 0.9 percentage points. When looking at lone mothers alone, however, he finds an effect of positive 0.6 percentage points that is not statistically different from zero. One of the reasons for this comparatively low estimate is the choice of sample period: using data from only just before and just after the policy introduction, which consequently fails to capture any delay in the effect of the policy change (Brewer and Browne 2006). Avoiding this pitfall is even more important in analysing the impact of WTC for childless people since the policy was entirely new.

2.27 The estimated positive employment effect of WFTC was greater than expected. In a number of predictive studies conducted before full evaluation was possible, the estimated effect of the policy was expected to be between positive 1.6 and 2.2 percentage points on the employment probability of lone mothers (Gregg et al. 1999, Blundell et al. 1998, Paull et al. 1999).

2.28 Research into in-work support in the United States, such as Eissa and Liebman (1996), looks at the increase in generosity of the Earned Income Tax Credit following the Tax Reform Act of 1986. In that paper the authors compare the changes in employment for women with and without children, and they find that the policy resulted in lone mothers' participation increasing by 2.8 percentage points in 1988-1990. Contrary to what theory would predict for this sort of in-work credit (without an hours-requirement), they find no evidence of a fall in hours worked by those in employment. This is in line with much past labour supply literature, which finds that hours worked are less responsive than participation to changes in the net wage.

2.29 So theory, and evaluation of similar previous policies for families with children, suggests that WTC for childless people would encourage low-wage workers into employment at 30 hours per week or more, while having no effect on high-wage earners' incentives. The next chapter describes the population for analysis and looks at ways of identifying the target group for the policy.

3 THE POLICY TARGET GROUP

3.1 This evaluation employs two techniques to evaluate the labour supply effect of the Working Tax Credit for childless people, by exploiting the policy's age threshold for eligibility. The two techniques are discussed in more detail in chapters 4 and 5, but before proceeding with the analysis, it is important to identify and describe the group of people under consideration. This chapter will also discuss how applicable the estimated impact of the policy on this limited group might be to the full childless WTC population. For the policy to have any labour supply impact, some people must be receiving WTC payments, so this chapter will consider take-up of WTC for childless people and how it developed in the years immediately after introduction.

POPULATION FOR ANALYSIS

Age restrictions

3.2 The challenge in evaluating a policy such as this is to identify a control group whose labour market outcomes would, in the absence of the policy, move in parallel with those of the treated group (see Chapter 4). Given that the employment outcomes of 24 and 25 year olds are unlikely to be radically different from each other, assigning WTC eligibility for childless people on the basis of their being 25 and over means that, locally, the age threshold acts as the next best thing to random allocation.

3.3 On the other hand, the convenience of using the age threshold for evaluative purposes limits the age range within which labour market outcomes can be said to be similar. For reasons discussed in Chapter 4, it would stretch the plausibility of the identifying assumptions of difference-in-difference analysis to compare the labour market outcomes of 24 year olds, who are not eligible for WTC and, say, 55 year olds who are. Consequently, the analysis limits the treatment group to those individuals aged 25 to 27, and the control group to individuals aged 22 to 24.

3.4 By comparing the labour market outcomes for people on either side of the 25 year age threshold, it is possible to estimate the local average treatment effect (LATE) as defined in Chapter 4. The key question for policy-makers is, then, how applicable are the policy effects identified for this limited age group, who make up only a portion of the childless WTC population, to the wider childless population. The answer depends upon how participation elasticities change for childless people of different ages. However, it is not unreasonable to take the estimated policy impact on people in their late 20s as a guide to the impact of the policy on the full population of childless individuals of working age. This is known as the average treatment effect (ATE – see Chapter 4).

Single individuals

3.5 The policy innovation of interest here is the introduction, for the first time, of a wage subsidy[1] for childless people. This analysis considers only childless individuals (those neither married nor cohabiting), and does not evaluate the policy effect on couples without children. It seems sensible to exclude couples from the analysis both for simplicity and because childless couple recipients make up less than 10 per cent of WTC claimants without children between the ages of 25 and 29[2] – the age band from which the analysis takes the treated group. Given such low coverage for young couples, identifying a policy effect would be impossible using a national survey not specifically

[1] WTC is not a wage subsidy in the strict sense of the term since it is based on household income rather than individual income. For single people, therefore, the description is more accurate.

[2] The Child and Working Tax Credit Statistics, HM Revenue & Customs, December 2005

designed for that purpose. Overall, single childless people comprise 69 per cent of people in the 22 to 27 year old cohort, the sample used in this analysis.

Disabled people

3.6 Disabled people are excluded from the sample since the availability of Disabled Person's Tax Credit from 1998 to 2003 meant that work incentives for this group did not change substantially in April 2003.

DETERMINING THE ELIGIBLE GROUP

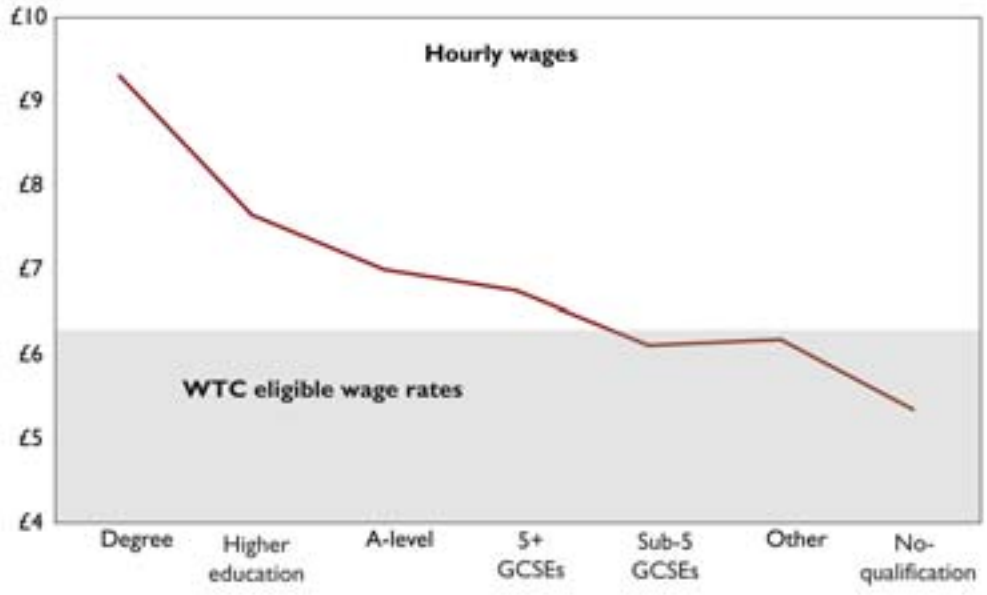
3.7 It is necessary for analytical purposes to make a further qualification on the group under consideration in this analysis. As a wage subsidy that reduces to zero at an individual income of around £11,000, the policy is, by construction, not aimed at more highly productive individuals with the capacity to earn wages above this level. For higher earners the financial return to working should be sufficiently high to provide strong work incentives without the need for a wage subsidy. Rather, the policy target group is potential workers with lower levels of productivity, and therefore lower potential wage levels.

3.8 In attempting to evaluate what impact the policy has on people's employment probability, identifying all potential beneficiaries, whether in or out of work, is crucial. Doing so for workless people is problematic, however, because it is impossible to know with certainty ex ante what a person is capable of earning in employment, and therefore whether they would be eligible for WTC payments.

Eligibility & low qualifications

3.9 To address this problem there are a number of good proxies for an individual's earning-power. Perhaps the strongest indicator of a person's productivity is their education level. Consequently the main approach taken in this evaluation is to identify the policy treatment group as those people with low qualifications. Chart 3.1 shows how the median hourly wage for single childless people varies with the level of their highest qualification. The grey area shows the level of wages for which a 35-hour working week would result in the person having entitlement to WTC (below about £6.25 per hour). At a lower number of weekly hours, people on wages of up to £7 per hour could be entitled to WTC.

Chart 3.1: Median hourly wages, people aged 22-27, by highest qualification



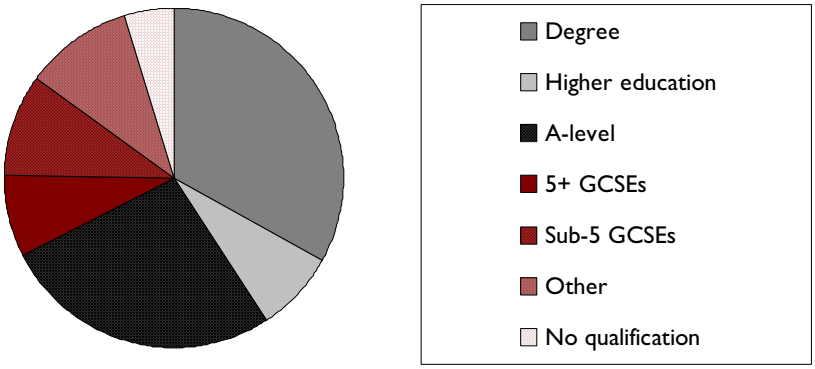
Source: Labour Force Survey 2001-05 and authors' calculations

Note: educational levels or equivalent

3.10 From the chart it is clear that most people with fewer than five GCSEs are entitled to WTC, while a large proportion of people whose highest qualification is five-or-more GCSEs would also be eligible. For the majority of people with a Level Three qualification (A-level or equivalent) or higher, entitlement to WTC would be zero or very low.

3.11 To give a feel for the distribution of qualifications in the sample under consideration, Chart 3.2 shows the proportion of single childless people at each qualification level. Those with qualifications of Level Two (five-or-more GCSEs) and below comprise around one third of the sample.

Chart 3.2: Highest qualifications for single childless people aged 22 to 27



Source: Labour Force Survey 2001-05

Eligibility and imputed wages

3.12 But a person's earning potential is dictated by more than just their educational qualifications. For example, pay rates for a given job can vary according to a person's age and where they live as well as, perhaps for discriminatory reasons, by their gender and ethnicity. It is possible to use the personal attributes of workless individuals captured in the survey data to predict or 'impute' the wage they might receive if they were to move into employment, based on the wages of employed people with similar characteristics. Imputed wage rates therefore form the second approach to determining the target group for the policy in this analysis.

3.13 Since workless people are likely to have poorer labour market characteristics (not least a broken work history), it stands to reason that the imputed wage distribution of workless people in the sample should lie to the left of that for employed members. Chart 3.3 shows these two distributions are as anticipated. The imputed wage distribution shows that just over 40 per cent of the sample have wages, or predicted wages, at or below £6.25 per hour and are thus entitled to WTC. This is comparable to the 33 per cent of the sample, described above, who have highest qualifications of Level 2 or lower.

Chart 3.3: Sample wage distributions

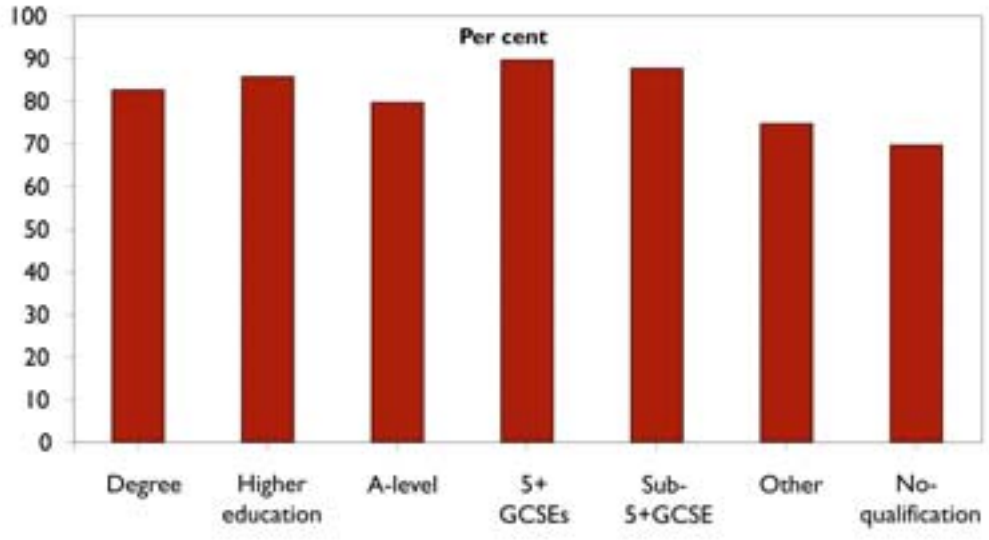
Source: Labour Force Survey and authors' calculations

SCOPE FOR POLICY IMPACT

3.14 As described in Chapter 2, families with children, particularly lone parents, have historically been the target of in-work support due to their relatively low employment rates. Low employment rates in the target group suggest that there is substantial headroom for the policy to have an impact in boosting employment rates. For childless people, however, pre-2003 employment rates were comparatively good. For this reason it would be unrealistic to assume that the labour supply effect of WTC for single childless people would be as large as that for lone parents.

3.15 Average employment rates for the population in this analysis were around 82 per cent for the period considered. However, there is some variation by qualification level. As Chart 3.4 shows, employment rates for people in the sample with no qualifications were 20 percentage points lower than for those with five or more GCSEs. This might indicate more scope for a large impact among people with the very lowest qualifications, or no qualifications at all.

Chart 3.4: Employment rates by highest qualification



Source: Labour Force Survey 2001-05

WTC RECIPIENTS IN THE ANALYSIS POPULATION

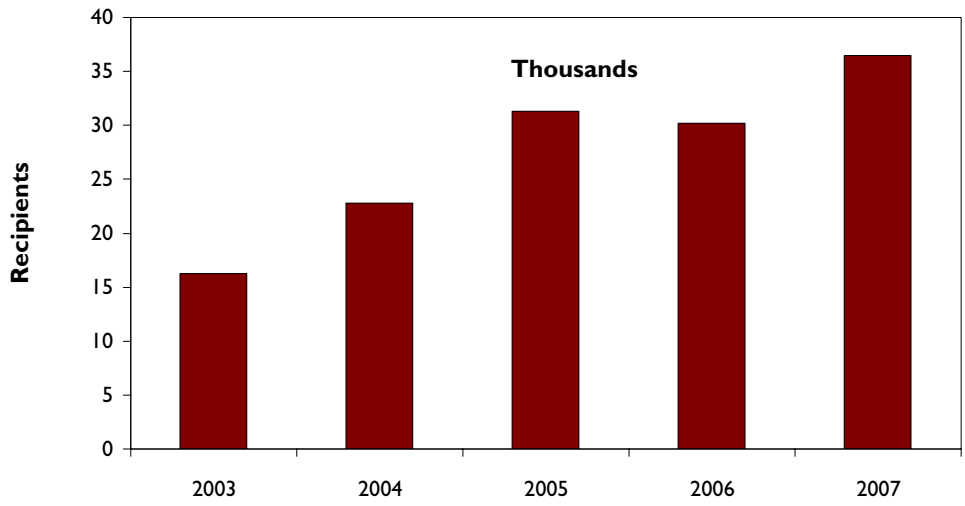
3.16 Before looking for a policy effect it's necessary to establish whether it was the case that some people were receiving WTC after April 2003. Unless some people claimed the credit it would be implausible to suggest that the policy had any effect in encouraging people to move into work.

3.17 Unlike in-work support for families with children, which is well established and has a high profile among the target audience, awareness of WTC for childless people is relatively low among the target group. Although the government would want people to take-up their tax credit entitlement, from a work incentives cost-effectiveness perspective, lower take-up may not be negative if it reflects the fact that only those responding to the new incentive take up the tax credit. Indeed, due to the relatively low profile of childless WTC, beneficiaries are less likely to be people who were in work before and remain in work after the policy change. Rather they are disproportionately likely to be those who have had contact with Jobcentre Plus after a spell out of work. Consequently the deadweight cost of the policy is potentially lower than for other groups for whom in-work payments are available.

WTC take-up

3.18 The rapidly growing take-up of childless WTC is consistent with this idea and with growing awareness of the policy among the target group. Between October 2003 and December 2005, take-up doubled among the 25 to 29 year old group. In recognition of the time it took for the new policy to bed-down, the sample for analysis includes observations from January 2001 to December 2005. Narrowing the window of observations demonstrates the relationship between the policy effect and the take-up rate. Chart 3.5 shows that take-up has continued to rise since 2005, and in December 2007 was 124 per cent higher than in October 2003.

Chart 3.5: Take-up among 25-29 year-olds



Source: HMRC Child and Working Tax Credits Statistics, 2003-07

DATA

Labour Force Survey

3.19 The analysis uses the Labour Force Survey (LFS). This is an extensively-used and nationally-representative UK panel survey, in which around 60,000 participants are interviewed for five consecutive quarters. The questionnaire covers a range of issues, including labour market behaviour and household characteristics. For the difference-in-difference (DiD) analysis, discussed in Chapter 4, it is essential to have observations for the sample before and after the policy's implementation in April 2003. Overall the sample used in the DiD analysis involves around 70,000 observations from people interviewed between January 2001 and December 2005. For the local linear regression approach, discussed in Chapter 5, observations are split into those occurring before and after the implementation of the policy.

3.20 It has been noted that the income data on the LFS is not particularly reliable (Dickens and Draca, 2005), particularly for the hourly pay-rate variable 'hourpay', not least because that variable is derived from weekly earnings and hours data. This makes determining eligibility through hourly earnings rates problematic. Consequently, the results derived from imputed wage rates, described in paragraph 3.12 should be treated with some caution.

Hours

3.21 Finally, the DiD analysis in Chapter 4 considers the impact of WTC on respondents' usual total working hours. Usual hours represent the important variable determining eligibility for WTC. Since the tax credits system is an annualised support regime that requires the claimant to report the number of hours worked in a typical week, reported 'usual hours' of work represent the best available data by which to determine entitlement. Since the LFS does not have a usual hours variable for anything other that a respondent's main job, the 'total hours' variable used here was derived by adding together respondents' usual hours in their main job and actual hours in any second job to account correctly for people who do more than one job.

3.22 However, reported hours remain problematic since it is not known how well hours of work reported in the LFS correspond to those reported to HMRC for

tax credits claim purposes. Further, where proxy responses[3] are concerned, reporting errors on hours of work in the LFS are known to be high. These issues are considered further below.

3.23 This chapter has described the sample under consideration. The next two chapters set out the analytical framework for, and present the central results of, the evaluation.

[3] A proxy response occurs when the survey was answered by an acquaintance on behalf of the target person, rather than that person answering directly.

4 Difference in difference evaluation

4.1 In an experimental setting, random assignment of treatment eligibility can ensure that the group with eligibility for the new policy and those without are identical in all but the fact of their eligibility, allowing a fair comparison to determine the policy impact. With a national policy, such random allocation is impossible and the evaluator must instead look for groups of people for whom the policy introduction simulates treatment and control groups. One technique for estimating the policy effect in such a setting is known as difference-in-difference (DiD) estimation and is the focus of this chapter.

Description of the method

4.2 This technique exploits the start of the policy to compare the outcomes of the target group before and after the policy launch. But straight-forward 'before-and-after' comparison assumes the counterfactual post-policy outcomes to be the same as for those observed before the start of the policy. This will obviously not be the case if macroeconomic or other changes affect the outcome of all those observed.

Identifying assumptions

4.3 Consequently DiD augments the before-and-after approach by employing a comparator group, unaffected by the policy, to track what outcomes would have been for the treated group in the absence of the policy. This control group is established on the basis of the two key identifying assumptions of DiD analysis. These are:

1. **common trend** between treatment and control groups; and
2. **no spillover** effect from the treated to the control group.

4.4 Under the **common trend** assumption, outcomes for the control group, such as employment rates or hours of work, are assumed to move in parallel with those of the treated group, even if they start at different levels. Comparing changes in employment rates over time between a treatment and control group allows the researcher to strip out any time-dependent changes, such as macroeconomic fluctuations, on the assumption that employment trends would have moved in parallel in the absence of the policy change. Assuming that the chosen control group is a sufficiently close match, any remaining effect can be considered to be the impact of the policy alone on the treated individuals.

4.5 If the control group is not a close match, however, it may be the case that macroeconomic changes affect the treated and untreated groups differently. This would bias the estimate of the policy effect. In the non-experimental setting of the national launch of WTC, it is impossible to find a group that matches the treated in all aspects but the fact of their treatment (i.e. a purely experimental control group). However, if one is prepared to assume that macroeconomic fluctuations have the same impact on the labour market prospects of 22 to 24 year olds as on those of 25 to 27 year olds, then the younger group can be used as a control group in the estimation. This assumption means that, before the policy's introduction, changes in employment probability for those in the control group should not be significantly different from changes for those in the treatment group.

4.6 Ideally an evaluation of WTC for childless people would aim to look at its impact on all potential recipients, rather than just those aged 25 to 27. However, as alluded to in Chapter 3, it is less plausible to assume that macroeconomic fluctuations affect older

workers in the same way as they affect people aged 22 to 24, the control group. For this reason the treated group for the purposes of this analysis is restricted to those aged 25 to 27, for whom the assumption of common trend is much more realistic.

4.7 Under the **no spillover** assumption, the policy should only affect outcomes for people in the treatment group. If changes in outcomes among the treatment have an effect on the control group, then the result will not reflect the true policy effect. For example, if childless WTC increased employment of 25 year olds at the expense of 24 year olds, results would show an exaggerated estimate of the policy impact on 25 year olds since the group assumed to represent the counterfactual was negatively affected by the policy. The validity of these assumptions will be tested below.

Basic DiD

4.8 Formally, the raw or basic DiD estimator is given by equation (1), where y is the outcome (probability of being in employment or number of hours worked each week). Subscript T represents those individuals and couples over 25, the treated group, while C represents those under 25, the control group. Subscript A represents those observations taken after policy implementation (April 2003), and B those taken before that time.

$$\hat{\theta} = (y_{TA} - y_{TB}) - (y_{CA} - y_{CB}) \qquad (1)$$

4.9 This estimator can be generated using the basic DiD regression model shown in equation (2). Here γ is a coefficient on the time dummy T, which is positive after the introduction of the policy and zero before. δ is the coefficient on the dummy variables denoted by A. These take the value of one if the respondent is over or under 25 (denoted by superscript 24 or 25) and if the respondent has high or low qualifications, respectively (denoted by subscripts H and L – these also represent high or low wages in the imputed wage model). Otherwise, the variable takes the value of zero. This means there are four categories of people in the sample, each represented by one of the A variables ($A_L^{24}, A_H^{24}, A_L^{25}, A_H^{25}$). The group eligible for the policy therefore includes those people over 25 with low qualifications (or imputed wages), identified by A_L^{25}. The excluded category for the A dummies is those under 25 and with low qualifications (or imputed wages), A_L^{24}. This is the control group.

4.10 Finally, θ_1, as the coefficient on the interaction term of low qualification people who are over 24 and in the post April 2003 world, is the DiD estimator. θ_2 and θ_3 are coefficients on two interaction variables that control for any changes in the high-qualifications group after the policy is introduced. In line with the A variables, the excluded interaction variable is the control group (people under 25 with low qualifications after policy introduction). ε_{it} is an i.i.d.[1] variable with a mean value of zero.

$$\begin{aligned} y_{it} &= \alpha + \gamma T_t \\ &+ \delta_1 A_{Li}^{25} + \delta_2 A_{Hi}^{25} \\ &+ \delta_3 A_{Hi}^{24} + \theta_1 (T \cdot A_L^{25})_{it} + \theta_2 (T \cdot A_H^{25})_{it} + \theta_3 (T \cdot A_H^{24})_{it} + \varepsilon_{it} \end{aligned} \qquad (2)$$

Regression-adjusted DiD

4.11 Two improvements can be made to this specification, aimed at generating a closer fit. First, by using a vector of individual characteristics **Z** it is possible to create a 'regression adjusted' DiD estimator (see equation (3)). This takes into account any differences between the treatment and comparison group that are not already accounted for by the time and treatment dummies. Secondly, to more accurately control for time variation a variable can be generated to control for macroeconomic

[1] Independently and identically distributed

fluctuations from year to year rather than simply using the blunt pre-/post-policy dummy. In equation (3) this variable is named DT, representing a vector of binary indicators for each year and replacing T from equation (2). This functional form is intuitively attractive since it can account for macroeconomic fluctuations over time more closely.

$$\begin{aligned} y_{it} &= \alpha + \beta \mathbf{Z}_i + \gamma DT_t \\ &+ \delta_1 A_{Li}^{25} + \delta_2 A_{Hi}^{25} \\ &+ \delta_3 A_{Hi}^{24} + \theta_1 (T \cdot A_L^{25})_{it} + \theta_2 (T \cdot A_H^{25})_{it} + \theta_3 (T \cdot A_H^{24})_{it} + \varepsilon_{it} \end{aligned} \qquad (3)$$

4.12 To overcome the usual problems encountered when estimating binary dependent-variable models by linear methods, this analysis uses a probit model to analyse participation. In the analysis of intensive labour supply, OLS is used.

4.13 In both cases, the DiD estimator θ_1 can be interpreted as measuring the average treatment effect on the treated group of 25 to 27 year-olds in the sample. Since the analysis compares people just either side of the age eligibility threshold, the parameter θ_1 is the local average treatment effect (LATE). As described above, in the absence of close control groups for all other ages, the quasi-experiment created by the age-eligibility criterion is the only robust way to measure the policy effect on recipients. Hence θ_1 can be considered to be the average treatment effect (ATE) on all eligible people only if a constant treatment effect for all age groups is assumed. Although participation elasticities are likely to vary across age groups, it is reasonable to take θ_1 as an indication of the impact of the policy on the entire treated group, including those older than 27.

RESULTS

4.14 This section describes the headline results using the DiD method. Looking across the whole spectrum of estimated policy effects, the key finding is that WTC resulted in a small but statistically significant increase in employment probability among the eligible group considered. This effect is robust to a range of tests and sensitivity analyses. The main results are reported below, with some other results reported in the Annex.

4.15 Table 4.1 shows the main results for the policy effect using qualifications and imputed wages to determine WTC eligibility. The introduction of WTC is estimated to have increased employment probability by 2.4 percentage points, when using a full vector of individual characteristics as controls. The impact is estimated to be up to 3.3 percentage points on the imputed wage basis, although this result is not statistically significant.

Table 4.1: Central DiD results

Employment probability	Basic DiD	Full vector of individual characteristics
Employed (low qualification eligibility)	2.3** (0.03)	2.4** (0.01)
Employed at 30+ hours excluding proxy responses (low qualification eligibility)	1.7 (0.32)	2.3 (0.20)
Employed (imputed wage eligibility below £6.25)	2.2 (0.35)	3.3 (0.15)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; 69,100 observations.

4.16 Looking at the effect of WTC on the probability of working at least 30 hours per week, the estimated effect is somewhat lower showing a 1.3 percentage point increase in the probability of being employed at over 29 hours (see Table A.1 in the Annex). But this presents an additional measurement challenge. It is difficult to be sure of the relevance of the hours reported in the Labour Force Survey (LFS) for two reasons. First it is not known how much correspondence there is between hours of work reported in survey data, those reported to HMRC for tax credits purposes and actual hours worked. Second, where LFS respondents answer survey questions by proxy (e.g. when the target respondent is out and someone else answers on their behalf), the rates of error for the hours worked data are among the highest in the whole survey[2].

4.17 Consequently, a good test is to exclude such responses and re-estimate on a smaller sample of direct respondents only[3]. Doing so yields an estimated policy effect of 2.3 percentage points, slightly lower than the headline result, but only significant at the 20 per cent level (this may partly be the result of the reduced sample size). The sensitivity of this result, however, is puzzling. It would be interesting to investigate further why proxy responses drive the difference between the two estimates for those working 30 hours. Due to the close correspondence between the result for the employment binary and that for the employed-at-30-hours binary once proxies are excluded, the former is taken to be the central result.

4.18 Chapter 2 considered the theoretical impact of the policy on hours worked, concluding that the net effect is theoretically ambiguous. Table 4.2 shows the estimated effect of the policy on hours worked among individuals in employment. The introduction of WTC is estimated to have decreased average hours worked by 0.7 hours, or around 40 minutes per week on average. However, the increase in the number of people employed offsets this effect resulting in no change in total hours worked among those eligible for the policy.

[2] See www.statistics.gov.uk/downloads/theme_labour/LFSUG_vol1_2007.pdf

[3] In the sample under consideration, almost half of responses are by a proxy.

Table 4.2: Policy effect on hours worked, GCSE and below

	Basic DiD	Full vector of individual characteristics
Average hours worked, all employed	-0.83** (0.02)	-0.70 ** (0.03)
Average hours worked, whole sample	0.22 (0.68)	0.36 (0.43)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; sample size ranges between 67,400 and 55,300.

Testing the identifying assumptions

4.19 Because of the nature of DiD estimation, which relies on a very reduced-form specification and few (but strong) assumptions, robustness tests under this technique tend to be minimal. The most frequently used method is to conduct tests on whether the DiD identifying assumptions hold for the sample. This is effectively a test on whether the analysis at hand is indeed a quasi-experiment. This approach is complemented by some sensitivity analysis and some further tests on inference efficiency.

4.20 The common trend assumption for DiD requires that, in the period before policy introduction, changes in the outcome variable should not be significantly different for respondents in the control and treatment groups. This assumption can be tested by running the various DiD regressions over the pre-policy period, including interaction terms between the treatment and time dummies (see Stewart 2004). A significant coefficient on an interaction term would mean that there is some time-varying effect which only affects one of the two groups, and which cannot be accounted for by the treatment, time or control vectors. To test this, the model represented by equation (3) was run with these interaction terms. All three outcome variables (probability of employment, probability of employment at over 30 hours, and total hours worked) are consistently non-significant. This validates the assumption of common trends for the treatment and control group.

4.21 In the context of WTC, the no spillover assumption, the second identifying assumption of DiD, implies that no general equilibrium effects are generated by the policy. The main possible source for such effects might be through employers' substitution of 'wage-subsidised' workers (those aged 25-or-over) for 'unsubsidised', younger workers. This is unlikely to be problematic however, and previous evaluative work for WFTC found no evidence of such substitution effects (Blundell et al., 2005).

Sensitivity analysis

4.22 Another issue concerning the DiD analysis is the sensitivity of the results to different definitions of policy eligibility and when applied to different groups of people. Table 4.3 looks at the policy effect for men and women separately. It shows that the effect is much stronger and significant for men, and statistically non-significant for women. Once again, while the coefficients remain positive when looking at the probability of working at least 30 hours per week, they also become less significant.

Table 4.3: Policy effect by gender, GCSE and below

Employment probability	Full vector of individual characteristics	
	Women	Men
Employed	0.5 (0.78)	3.1*** (0.01)
Employed at 30+ hours	0.1 (0.98)	1.7 (0.25)
Employed at 30+ hours excluding proxy responses	2.6 (0.37)	2.1 (0.34)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; sample size varies between 41,200 and 27,800 observations.

4.23 As discussed in Chapter 3, those with the lowest qualifications would be expected to have the lowest potential earnings and therefore to benefit most from WTC. This, combined with their relatively low employment rates, would lead one to anticipate a stronger policy effect as the treated group narrows to those with the lowest qualifications.

4.24 Table 4.4 shows the effect of WTC using different qualifications as a proxy for eligibility. Consistent with theory, the estimated policy impact on employment probability increases the lower the level of qualifications. The table shows that the employment effect for people whose highest qualification is a full set of GCSEs is 2.4 percentage points (this is the central result reported in Table 4.1, above). Looking at those with fewer than five GCSEs, the effect is bigger, at 3.0 percentage points. Those with other or no qualifications are estimated to be 4.0 percentage points more likely to be employed following WTC introduction.

Table 4.4: Policy effect, for various skill levels

Employment probability	Basic DiD	Full vector of individual characteristics
GCSE and below	2.3** (0.03)	2.4** (0.01)
Fewer than 5 GCSEs and below	2.3** (0.04)	3.0*** (0.00)
Other qualification and no qualifications	3.5*** (0.01)	4.1*** (0.00)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; sample size 69,100 observations.

4.25 Another issue addressed in the previous chapter was the rapid rise in take-up and awareness of childless WTC in the months after its introduction (see Chart 3.5). This might lead one to expect a weak initial policy impact getting stronger in later years.

4.26 Table 4.5 looks at how the estimated WTC effect on employment probability changed over time. Looking at the effect of WTC up to the end of 2003 shows that the initial effect was indeed small, and not statistically different from zero. When the sample is extended to include data up to the end of 2004, the policy effect is estimated to be 2.0 percentage points. Including data until the end of 2005 yields the same headline effect from tables 4.1 and 4.4, an estimated effect of 2.4 percentage points. Consequently these results are as anticipated.

Table 4.5: Policy effect for different treatment years, GCSE and below

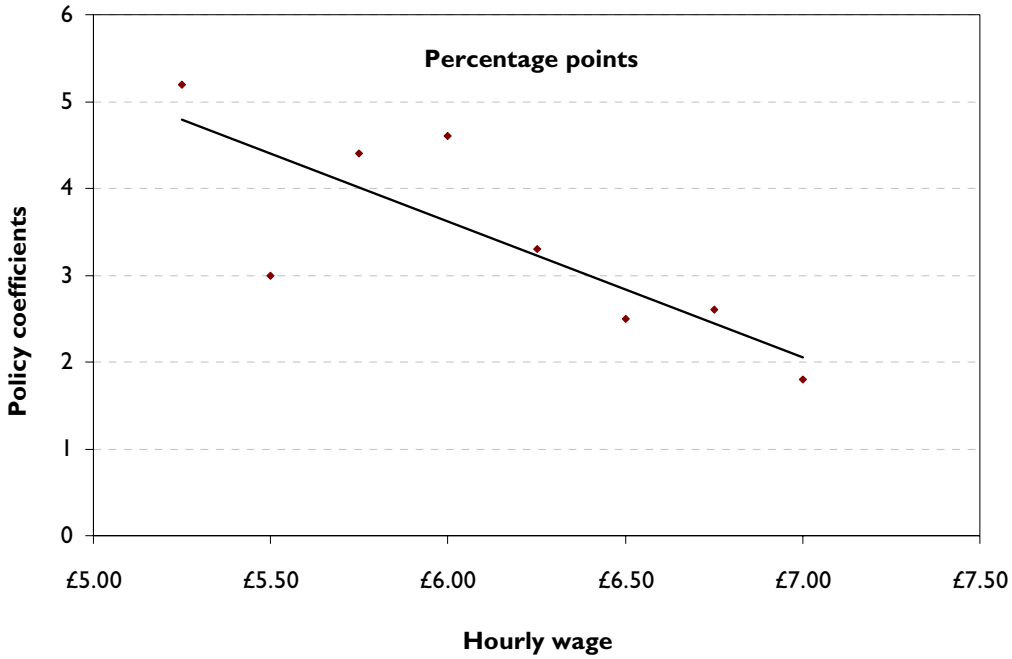
Employment probability, treated group year	Basic DiD	Full vector of individual characteristics
2003	0.5 (0.73)	0.7 (0.61)
2003-04	2.0* (0.08)	2.0* (0.07)
2003-05	2.3** (0.03)	2.4** (0.01)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; sample size varies between 43,200 and 69,100 observations.

4.27 Chart 4.1 (and Table A.4 in the Annex) shows the estimated impact of WTC introduction using imputed wages of workless people in the sample to determine eligibility for WTC, as described in the last chapter[4]. Most of the effects are not statistically different from zero. Encouragingly, however, the estimated coefficients increase the lower the imputed wage cut-off, which determines how much the recipient is likely to benefit from WTC. At the lower end of the scale, from £6.25 downwards, the effect becomes statistically significant.

[4] Wage imputation regression included controls for age, gender, qualifications, ethnicity, employment experience, housing tenure, students and region of residence.

Chart 4.1: Sensitivity analysis around the wage rate determining treatment



Source: authors' analysis

Robustness tests

4.28 While the test of the identifying assumptions and the sensitivity analysis above goes some way to confirming the robustness of the estimates reported, there are two further robustness checks that are commonly performed. The first consists of narrowing the age band of the people in the sample, from 22 to 27 down to 24 and 25, to see if it affects the result. Doing so shows that the central estimates are stable (see Table A.3 in the Annex).

4.29 Finally, the robustness of these results can be tested by measuring the effect of WTC on employment at some alternative date when there was no policy introduction. If the DiD approach is correct, the estimated policy effect at these spurious introduction dates should not be statistically different from zero. Table A.2 (see Annex) shows that there was no statistically or economically significant effect at the false policy start dates of April 2002 and April 2004.

5 Regression discontinuity evaluation

5.1 As explained in Chapter 2, the Working Tax Credit (WTC) is not the only policy for which entitlement changes at the age of 25. At that point, single childless individuals become eligible for increased Housing Benefit, greater levels of Income Support/Jobseeker's Allowance, and also cease to be eligible for participation in the New Deal for Young People (NDYP). In theory, these policy changes reduce the probability of being in employment, as they either increase out-of-work income or they increase the effective cost of being hired.

5.2 Against this, theory also predicts that the newly-introduced WTC would increase the probability of being in employment, by boosting in-work disposable income. Thus, theoretically, these two opposing forces result in an ambiguous net effect – but one that can be estimated empirically. The previous chapter focused on isolating the impact of WTC. This chapter exploits the sudden change in young people's work incentives at the age of 25 to measure the net effect of the policy environment on the probability of employment both before and after WTC introduction.

The RD approach

5.3 A Regression Discontinuity (RD) technique is used to measure the overall impact of policy on the employment of low-wage people. The technique can be applied in a situation where an individual's treatment depends upon an observable characteristic, in this case age, where there is a known point at which the probability of treatment changes discontinuously. The idea is that in the neighbourhood of the discontinuity, treatment is effectively randomly assigned. It is for this reason that RD is sometimes referred to as a quasi-experimental design. For this application, since treatment is a deterministic function of age, the policy changes represent a 'sharp' discontinuity: the probability of being treated jumps from zero to one as an individual turns 25.

5.4 In applying this method to evaluation of WTC, this analysis takes a similar approach to that in the study by De Giorgi (2005), where RD is used to measure the effect of the NDYP. The design of that policy also presented a discontinuity around the age of 25, when people stopped being automatically eligible for the job-search assistance programme. He exploits that discontinuity to identify an increase in the employment probability of 6-7 per cent.

DESCRIPTION OF THE METHOD

Non-parametric model

5.5 There are various ways of using the RD approach to estimate the treatment effect of the various policy changes at 25. A parametric approach is similar to the difference-in difference models explained in the previous chapter. This analysis, however, uses a non-parametric method. This variant of the technique avoids the need for imposing a pre-determined structure on the data, giving it the flexibility to define its own shape. Furthermore, not assuming a specific functional form for the data enables identification of possible lagged or anticipated responses to the policy changes at age 25.

5.6 By performing a local linear regression (following Fan 1992) on each side of the age threshold it is possible to estimate the function g in regression equation (4) for the group under 25 and for those 25-and-over. Given the changes in the policy environment at 25, it might be anticipated that the result will show a discontinuity between the two regression functions.

$$y_i = g(x_i) + \varepsilon_i \tag{4}$$

The function, g, is estimated for the whole sample by finding the local linear estimate of employment probability given age:

$$E[y_i|x] = \hat{g}(x) \tag{5}$$

where

$$(\hat{g}(x)) = \text{argmin}_{\hat{g}(x)} \sum_{i=1}^{n} (y_i - g(z_i - z_0))^2 K\left(\frac{z_i - z_0}{h}\right) 1(z_i - z_0) \tag{6}$$

In expression (6), h represents the bandwidth used to smooth the regression. Z_0 denotes the value of the regressor at which estimation is performed and Z_i represents other points away from Z_0 that influence the estimation of the outcome at Z_0. In this kernel estimation approach, the bandwidth determines the maximum distance of observations away from Z_0 that contribute to the point estimates. This procedure is repeated for a number of points along the age axis, yielding an estimate of the true function underlying the data. The kernel function used is the Epanechnikov kernel[1]. This function weighs observations close to the point being estimated higher than it does those further towards the extremes of the bandwidth (unlike, for example, the uniform kernel). The Epanechnikov kernel is used because it seems most intuitively appropriate for this purpose. However, none of the commonly used kernels obscure the salient points of the regression plots produced in this analysis.

A semi-parametric variant

5.7 Here, too, improvements can be made to the model by controlling for characteristics other than age. An important limitation on the non-parametric approach is that it is difficult to include many variables in the regression. One way around this is to use a model of the following form:

$$y_i = \beta \mathbf{Z}_i + g(x_i) + \varepsilon_i \tag{7}$$

where $\mathbf{Z}_i$ is a vector of individual characteristics. This kind of semi-parametric model is estimated by first generating parametric coefficients for β. Then, from each value of y_i is subtracted the estimated coefficients given by the parametric regression (the sum of the estimates for β multiplied by the values of $\mathbf{Z}_i$) for the given observation. This is represented in equation (8).

$$y_i - \beta \mathbf{Z}_i = g(x_i) + \varepsilon_i \tag{8}$$

5.8 By this process, the resulting dependent variable has now been stripped of the effects contained within the control vector, allowing a local linear regression to be performed to generate an estimate of the function, $\hat{g}(x)$, in the same way as before.

Estimation issues

5.9 There are three issues that need to be considered in the context of RD estimation. First, the technique presents a trade-off regarding the bandwidth to be used for smoothing. With an insufficient sample size a small bandwidth causes the local regression to suffer from noise that obscures the underlying function. Too large a bandwidth, on the other hand, can result in estimates of the underlying function being biased if observations at the extremes of the local regression are systematically different from those at its centre.

[1] The Epanechnikov kernel is $K(u) = \frac{3}{4}(1 - u^2) I(|u| \leq 1)$, where $u = \frac{z_i - z_0}{h}$.

5.10 Second, when moving up the age groups from 20 to 33 (the age range of the sample used in the RD) there may be other effects at play. For example, it may be the case that the sample is not randomly selected due to the fact that living arrangements and fertility decisions are endogenous, so the group of single childless people at 33 is systematically different to that at age 20. However, as long as these effects occur as a smooth function of age, the existence of a discontinuity at 25 can be attributed to the local impact of the policy.

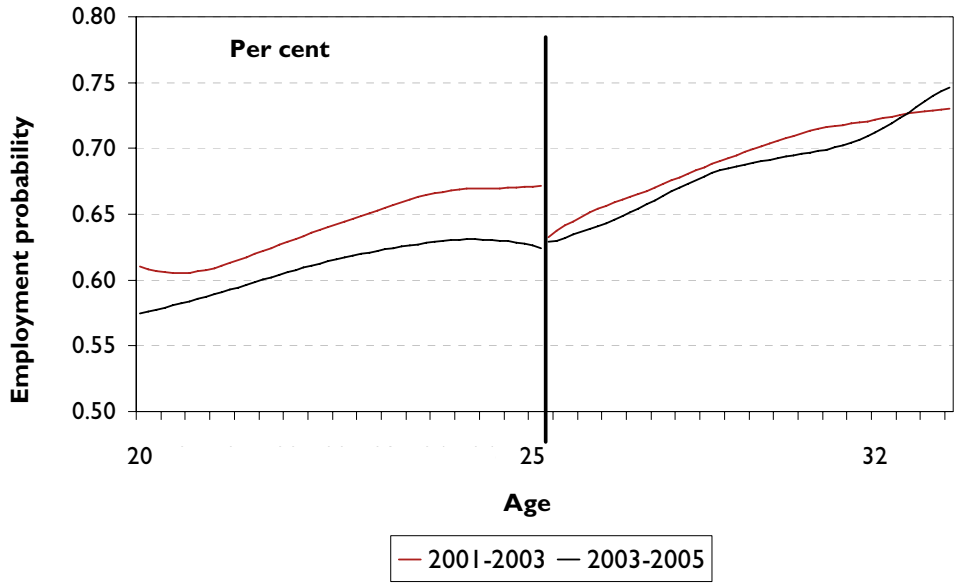
5.11 Third, RD can be invalidated if the observable characteristic on which eligibility is determined can be manipulated through people misreporting their age. With social security numbers being used to determine age, this does not present a threat to the validity of the technique in this application. As with DiD, a possible further threat is posed by general equilibrium effects, but, as discussed in Chapter 4, these are not thought to be significant.

RESULTS

Non-parametric results

5.12 A bandwidth of one year is used for the non-parametric local linear regression of employment probability on age. First, local linear regressions are run either side of the threshold age of 25. The resulting plots for the data from before the introduction of WTC (red line) show a clear discontinuity in the regression, with employment as a function of age falling by around 3.9 percentage points at the age of 25 on an otherwise steadily upward-trending line (Chart 5.1). After the introduction of the new policy (black line), employment levels among the eligible groups show evidence of a small positive discontinuity at the age the policy environment changes, although this jump is not statistically different from zero.

Chart 5.1: Non-parametric local linear regression of employment on age

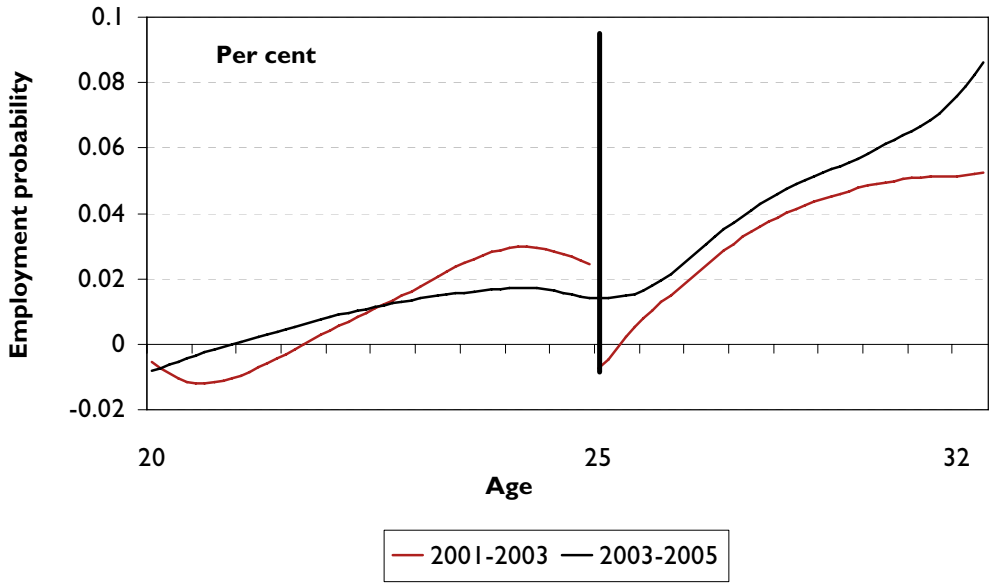


Source: authors' analysis

Semi-parametric results

5.13 More interesting, perhaps, is the result of the semi-parametric local linear regression, which is represented in Chart 5.2 (using a bandwidth of 1.2). It clearly demonstrates the net impact of the policies that change at the age of 25. These regressions, which control for other characteristics of respondents, give an indication of the effect on participation of the increased generosity other benefits (theoretically a negative effect) before April 2003, represented by the red line. The black line represents the relationship after April 2003, when all of the policies mentioned above were in operation alongside the new WTC.

Chart 5.2: Semi-parametric local linear regression of employment on age



Source: authors' analysis

5.14 For data from the two years before April 2003, the regressions show evidence of a large discontinuity at 25, attributable to the policy environment and causing the age-contingent probability of employment to fall by around 3.2 percentage points. There is also evidence that since the introduction of WTC the detrimental impact of policy on participation around age 25 appears to have been effectively countered, with no evidence of a discontinuity at that age in the data since 2003. Again, this change in the age function can be attributed to the introduction of WTC.

Determining standard errors

5.15 Some robustness checks were conducted for the discontinuity estimates. One way of allowing inference is to use bootstrapping. This has to be done manually when using non- and semi-parametric methods, as in the case of the local linear regressions. Using the bootstrapped standard errors (after 300 replications[2]) the semi-parametric regression discontinuity estimate for the pre-WTC data is found to be statistically significant (see Table 5.1), while there is no statistically or economically significant discontinuity in the 2003-05 data.

[2] While a higher number of replications would be desirable, computational time is high. Improvements in replication size are planned.

5.16 As in Chapter 4, another way of testing for robustness is to run the estimation procedure across an age threshold at which no change in the policy environment occurs, to check that that the procedure does not suggest the existence of any discontinuity. This is done for hypothetical discontinuities at age 23 and 28: neither resulting regression discontinuity coefficient is statistically different from zero. It is therefore reasonable to conclude that the regression discontinuity estimates are robust.

Table 5.1: Regression discontinuity estimates

Local linear regressions	Non-parametric	Semi-parametric
Pre-WTC (2001-03)	-0.0386**	-0.0319**
	(0.0166)	(0.0158)
Post-WTC (2003-05)	0.0045	-0.0003
	(0.0147)	(0.0132)
Bandwidth	1 year	1.2 years

Eligibility defined by low qualifications
Bootstrapped standard errors in parentheses (300 replications)
** denotes significance at the 5 per cent level

5.17 That participation appears to begin falling just before the age of 25 may indicate an anticipation effect. It is possible that, a few months before they become eligible for the more generous IS, some individuals who have become unemployed decide to remain jobless in order to be able to claim it. This is not implausible since would-be claimants are not eligible for IS if they have voluntarily left unemployment in order to claim.

5.18 However, the explanation could also lie in the technique employed. Use of a kernel estimator (rather than employing a nearest neighbour technique) means that local regressions near to the discontinuity have a higher variance than those in the middle of the regression. This occurs because, at the very edge of the plot (the point of discontinuity), the regression is determined by observations on only one side of the evaluation point, thus halving the amount of data available at other points in the regression[2]. As a result it is difficult to draw firm conclusions about the existence of any anticipation effect.

5.19 The last two chapters have considered the impact of WTC at and shortly after its introduction. In concluding, Chapter 6 draws together the key findings and briefly discusses developments in policy since 2003.

[2] Using a nearest neighbour method would resolve this problem, but unlike the kernel approach would bias the estimate at the point of discontinuity.

6 Conclusion

6.1 Chapters 4 and 5 described in detail the two analytical techniques employed and results found in this evaluation of the labour supply impact of the Working Tax Credit (WTC) for childless individuals. In concluding, this chapter briefly summarises the key findings of the analysis. It goes on to describe what impact the recent evolution of the tax and tax credits environment may have had on the labour supply of low-skilled workers in the light of these findings. The chapter ends by considering the implications of this evaluation for future policy.

WTC and labour supply

6.2 Working Tax Credit was introduced as part of a broader package of reforms to financial support for families in April 2003. The policy included in-work financial support for low-paid individuals and couples without children, for the first time on a national basis in the UK. This evaluation has focused on the impact of the policy on the labour supply of childless single people.

6.3 Among this group of the population WTC eligibility is not only work-contingent, but also age-contingent, with only those aged 25-or-over able to claim. For the age group just either side of the 25-year eligibility threshold, therefore, this means that in-work financial support is all but randomly assigned. In employing two quasi-experimental evaluation methods, difference-in-difference (DiD) and regression discontinuity (RD) analysis, this research identified the impact of the policy on the employment probability and hours worked of the target group.

Employment impact

6.4 The main findings of this paper were:

- The introduction of WTC had a small positive effect on the number of people employed, with WTC estimated to have increased the employment probability of eligible people by 2.4 percentage points when low **qualifications** are used as a proxy for eligibility;
- When using **predicted wages** based on individual characteristics to determine WTC eligibility, the estimated effect of the policy on employment probability is positive 3.3 percentage points, but this result is less reliable than the one using qualifications as a proxy;
- The effect of WTC on employment probability appears to be concentrated among **men**, with no evidence of an increase in the employment probability of WTC-eligible women in the sample;
- The policy impact was estimated to grow in line with **take-up**, from a positive 0.7 percentage point effect in 2003 alone, to positive 2.4 percentage points when data from 2003 to 2005 is analysed;
- The policy raised employment probability most for among people with the **lowest qualifications**; for people with five-or-more GCSEs WTC raised employment by 2.4 percentage points, while for those with the lowest or no qualifications the impact was 4.0 percentage points;

- WTC is estimated to have led to a small decrease in **average hours** worked among those in employment, but the increase in the number of people employed offsets this effect, leading to no change in total hours worked among those eligible for the policy; and
- Prior to introduction of WTC, it is found that the wider policy environment induced a substantial deterioration in employment probability, of around 3.2 percentage points, when people became 25. The introduction of **WTC ameliorates this pre-existing deterioration in work incentives at age 25**, with no evidence of a sudden drop in employment probability found at age 25 following the introduction of the new policy.

DEVELOPMENTS SINCE 2003

Policy developments 2003 to 2008

6.5 Since the introduction of tax credits, the relevant elements of the WTC have been up-rated in line with prices and have therefore maintained their value. The Tax credits income threshold, the income level above which tax credit entitlement begins to be withdrawn, was set at £5,060 per year in 2003. The threshold was increased to £5,220 in 2005-06 and remained at that level until the introduction of the Budget 2007 reforms in April 2008. The withdrawal rate of tax credits remained unchanged throughout this period at 37 per cent, while the income tax personal allowance rose in line with prices.

6.6 Gains to work for a full-time single person earning £5.52 per hour jumped from £43 to £61 per week as a result of the introduction of WTC[1]. The net effect of these changes between April 2003 and March 2007 was broadly to sustain the improvement in work incentives represented by the launch of WTC.

6.7 The calculations of gains to work above, however, ignore the effect of the changes to the disregard in tax credits. Where income rises by less than the disregard between years, a tax credit claimant's award is not affected for the remainder of that year; this can be particularly beneficial to people moving into work after a period of being out of work. The disregard increased from £2,500 to £25,000 in April 2006, which could further boost work incentives in the first year back in work.

Policy changes from April 2008

6.8 Reforms to income tax and tax credits rates, announced in Budget 2007, altered the work incentives for all childless WTC recipients. The changes, to be implemented from April 2008, include the abolition of the 10p income tax band and a reduction in the 22p rate to 20p. Tax credit recipients benefited from a £1,200 increase in the annual tax credits threshold, to £6,420 per year. There was also an increase in the withdrawal rate of tax credits from 37 per cent to 39 per cent. This left marginal deduction rates for tax credits recipients unchanged but with most receiving higher tax credit awards along side slightly higher gross income tax liability. Most WTC recipients were, as a result, paying lower levels of net tax.

6.9 The overall work incentives impact of these changes for the lowest-income childless individuals was positive. For such a person on the April 2008 National Minimum Wage, the Budget 2007 reforms lower the average effective tax rate from 70.2 per cent to 68.9 per cent and increase the gain to work by £2.45 per week. For childless individuals, while beneficial, this change is small by comparison with that of April 2003. Consequently the Budget 2007 reforms are unlikely to have any significant additional effect on the labour supply of childless individuals receiving tax credits.

[1] All figures in constant 2008-09 prices. £5.52 was the adult National Minimum Wage rate in force in April 2008.

IMPLICATIONS FOR FUTURE POLICY

6.10 There are estimated to be around 1 million entitled non-recipients of WTC for childless people, along with a further group of workless non-recipients who would benefit from the support on offer were they to take up employment. Given the scale of the population this policy was designed to help and the rapidly growing take-up, the positive effect found in this analysis is of substantial importance as a guide to the future policy regarding this section of the population, which had not previously been entitled to such support.

6.11 In part, WTC for childless people was introduced as the corollary of the National Minimum Wage. This evaluation has shown that the policy was effective in encouraging people into work. As such, childless WTC points the way to a sustainable strategy for tackling worklessness and poverty by creating cost-effective work incentives, without the need for substantially higher minimum wages.

A ADDITIONAL RESULTS

Table A1: DiD policy effect, employed for 30 hours including proxy responses

Employment probability	Basic DiD	Full vector of individual characteristics
Employed at 30+ hours	0.6 (0.59)	1.3 (0.30)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; 69,067 observations.

A.1 Table A2 reports the results of a robustness test for the DiD estimator. The test is conducted by re-estimating a variant of the regression-adjusted DiD model (3) at two spurious dates, to see if there is any effect from policy introduction when in fact no policy change took place. It can be seen that the LATEs are not significantly different from zero when the hypothetical dates of policy introduction are April 2002 and April 2004. On the other hand, the estimated LATE when the policy changes in April 2003 is close to the central result reported in Table 4.1 (the small difference is due to the narrowing of the sample needed to allow comparison between these three alternatives).

Table A2: Robustness test: Policy effect on employment probability, GCSE and below

'Start date' of policy	Full vector of individual characteristics
April 2002	-0.9 (0.52)
April 2003 (real start)	2.3* (0.07)
April 2004	0.8 (0.56)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; sample size ranges between 32,800 and 40,800 observations.

A.2 Table A3 reports the results of a sensitivity test for the DiD estimator. The test is conducted by re-estimating a variant of the regression-adjusted DiD model (3) for different age groups. It can be seen that the estimated effect of policy does not vary significantly.

Table A3: Sensitivity of policy effect on employment probability, GCSE and below, narrowing age bands

Sample age range	Basic DiD	Full vector of individual characteristics
22 to 27	2.3** (0.03)	2.4*** (0.01)
23 to 26	2.3** (0.05)	2.0* (0.06)
24 to 25	4.3*** (0.01)	3.7** (0.01)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level, ** at the 5 per cent level and *** at the 1 per cent level; sample size ranges between 69,000 and 22,800 observations.

Table A4: Policy effect on employment probability, by imputed wage

Treated group	Full vector of individual characteristics
£7.0	1.8 (0.37)
£6.75	2.6 (0.21)
£6.50	2.5 (0.26)
£6.250	3.3 (0.15)
£6.00	4.6* (0.05)
£5.75	4.4* (0.09)
£5.50	3.0 (0.30)
£5.25	5.2* (0.09)

Note: marginal effects reported; p-values in parentheses; * denotes significance at 10 per cent level; sample size is 14,600.

BIBLIOGRAPHY

Adam, C (2004) *Seven Habits of Effective Reviewers: A checklist for effective evaluation of econometric evidence.*

Angrist, J.D. and Krueger, A.B. (1999) *Empirical Strategies in Labour Economics* in Ashenfelter and Card ed. *Handbook of Labour Economics Volume 3.*

Battistin, E. and Rettore, E. (2003) *Another Look at the Regression Discontinuity Design.* Cemmap Working Paper CWP01/03

Blundell, Duncan, McCrae and Meghir (1998), *The Labour Market Impact of the Working Families' Tax Credit,* IFS Report to the Bank of England Monetary Policy Committee, December.

Blundell, Brewer and Shepherd (2005) *Evaluating the impact of Working Families' Tax Credit using Difference-in-differences.* HM Revenue & Customs

Blundell, Brewer and Shepherd (2004) *The Impact of Tax and Benefit changes between April 2000 and April2003 on Parents' Labour Supply.* IFS Briefing Note No.52

Blundell and Costa Dias (2000) *Evaluation Methods for Non-Experimental Data.* Fiscal Studies col. 21, no.4, pp.427-468

Blundell and Reed (2000) *The Employment Effects of the Working Families' Tax Credit.* IFS Briefing Note No. 6

Brewer and Browne (2006) *The effect of Working Families' Tax Credit on labour market participation.* IFS Briefing Note No.69

Brewer, Duncan, Shepherd and Suarez (2003) *Did Working Families' Tax Credit Work? Analysing the impact of in-work support on labour supply and programme participation.* Inland Revenue

Brewer, Duncan, Shepherd and Suarez (2005*) Did Working Families' Tax Credit Work? The final evaluation of the impact of in-work support on parents' labour supply and take-up behaviour in the UK.* Inland Revenue

Connolly and Gregory (2002) *The National Minimum Wage and Hours of Work: Implications for Low Paid Women.* Oxford bulletin of economics and Statistics, 64

De Giorgi (2005) *Long Term Effects of a Mandatory multistage Programme: The New Deal for Young People in the UK.* IFS Working Paper W05/08

Dickens and Draca (2005) *The Employment Effects of the October 2003 Increase in the National Minimum Wage.* Queen Mary, University of London Working Paper No. 532

DiNardo and Lee (2002) *The Impact of Unionization on Establishment Closure: A Regression Discontinuity Analysis of Representation Elections.* NBER Working Paper 8993

DiNardo and Tobias (2001) *Non-parametric Density and Regression Estimation.* The Journal of Economic Perspectives, Vol. 15, No. 4, pp. 11-28.

Eissa and Liebman (1996) *Labour Supply Response to the Earned Income Tax Credit.* The Quarterly Journal of Economics, Vol. 111, No. 2, pp 605-637

Francesconi and Van der Klauuw (2004) *The Consequences of 'in-work' Benefit Reform in Britain: New Evidence from Panel Data.* ISER Working Paper No 2004-13

Greene, W *Econometric Analysis*. New York University, Prentice Hall

Gregg, Johnson and Reed (1999) *Entering Work and the British Tax and Benefit System,* Institute for Fiscal Studies, London, March

Gregg and Harkness (2003) *Welfare Reform and Lone Parent Employment in the UK.* Department of Economics and Leverhulme Centre for Market and Public Organisation, University of Bristol

Hanh, Todd and Van der Klauuw (2001*) Identification and Estimation of Treatment Effects with a Regression-Discontinuity Design.* Econometrica, Vol. 69, No. 1, pp 201-209

HM Treasury (2002) *The Child and Working Tax Credits: The Modernisation of Britain's Tax and Benefit System. Number 10.*

HM Treasury (2005) *Tax Credits: Reforming financial support for families. The Modernisation of Britain's Tax and Benefit System. Number 11.*

Leigh, A. (2005), '*Optimal design of earned income tax credits: evidence from a British natural experiment'*, Australian National University, Centre for Economic Policy Research, Discussion Paper 488.

Lemieux and Milligan (2004) *Incentive Effects of Social Assistance: A Regression Discontinuity Approach.* NBER Working Paper 10541

Low, H. (2004) Presentation: '*How Effective are in-work Tax Credits? New Perspectives'.* LSE Taxation Seminar, March

Lydon and Walker (2004*) Welfare-to-Work, Wages and Wage Growth.* Inland Revenue

Marsh, A. Stephenson, A. Dorsett, R. and Elias, P. (2001) *Earnings Top-up Evaluation: Effects on Low Paid Workers.* Policy Studies Institute on behalf of The Department of Social Security

Moffitt, A (2003) *The Negative Income Tax and the Evolution of U.S. Welfare Policy.* Journal of Economic Perspectives, Vol. 17, No. 3, pp 119-140

Myck and Reed (2000) *Labour Supply Estimation Project: Report 1.* IFS for HM Treasury

Paul, Walker and Zhu (1999) *Child support reform: some analysis of the 1999 White Paper,* Institute for Fiscal Studies, London, October

Smith, J (2004) *Evaluating Local Economic Development Policies: Theory and Practice.* University of Maryland

Stewart, M.B. (2004) *The impact of the introduction of the UK Minimum Wage on the employment probabilities of low-wage workers.* Journal of the European Economic Association, 2(1), p.67-97

Stewart and Swaffield (2004) *The Other Margin: do Minimum Wages cause Working Hours Adjustments for Low-wage Workers?* Low Pay Commission.

Stewart and Swaffield (2005) Conference paper, RES conference 2005.

Stine, R. (1989) *An Introduction to Bootstrapping Methods.* Socialogical Methods and Research, Vol. 18, No. 2 & 3

Wooldridge, J (2001) *Econometric Analysis of Cross Section and Panel Data.* MIT Press, Cambridge, Massachusetts

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